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TRACES OF ANCIENT GLACIERS IN THE WHITE
MOUNTAINS OF NEW HAMPSHIRE.

BY GEORGE L. VOSE.



PROBABLY few of the tourists who ride up the valley of the Androscoggin, from Bethel to Gorham, upon a hot August afternoon, would be quite prepared to believe that at some former period a solid river of ice filled that valley, for hundreds of feet in depth, and many miles in length, moving with a slow but irresistible march downwards, and that this huge glacier was continually supplied with fresh material at its upper end, from the vast snow-fields beneath which the White Mountains were perpetually buried. Yet there is evidence upon the ground that such was the case. All along the route the rocks are carved with hieroglyphics, more ancient by far than those of Egypt and the Nile, which, by means of the key obtained in the Alps, we are enabled to read.

In the mountains of Switzerland and of Italy, immense bodies of snow accumulate in the more elevated regions, where it is so cold that melting to any considerable extent is impossible, even in the summer. This snow is by a very gradual process converted into ice, immense bodies of which fill the higher Alpine valleys, and, urged by the pressure of

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the unconsolidated snow at the upper part of the mass, move down at the rate of from three hundred to five hundred feet in a year. The moving of a mass of ice, it may be a dozen miles in length, a mile wide, and a thousand feet deep, is attended by a tremendous grinding upon the rocks over which the glacier passes. By extended examinations geologists have become convinced that in old times these great bodies of ice covered immense tracts where now no ice is seen, and nothing but the polishing and scratching upon the ledges remains. This furrowing and polishing resembles so exactly the results now being produced beneath the present glaciers of the Alps, as to be regarded as positive evidence of the movement in a former age of vast bodies of ice over the rocks so scored.

There is at first sight a marked difference between the glacial furrows and polishing in the Old World and in the New. In Europe these marks upon the rocks are found in certain mountain regions, and always referring us by their direction to the higher parts of the mountain groups; thus showing that the glaciers moved down from the higher to the lower lands. This is plainly seen in the Alps, in Scandinavia, and Great Britain. In America, the traces upon the rocks, as a general thing, appear to have been produced by a far more wide-spread operation, inasmuch as the furrows have a prevailing southerly direction, regardless of topographical features to a remarkable extent, as they pass directly over and across some of the largest ranges of mountains. Throughout New England, the most common course of the furrows is about s.s.e. The wide extent of these traces would seem to point to some very general operation as a cause. What this operation was, or rather precisely how it worked, is by no means yet understood by geologists; nor does it concern us here, as the object at present is to call attention to a different class of glacial traces, which appear to show, contrary to the opinion for a long time held, that besides this general operation, which may be

traced over so wide an area, there have been what may be termed local glaciers,—masses of ice which belonged especially to certain mountain groups, and moved down the large valleys, leaving marks upon the rocks over which they passed, according in direction with the course of the valleys, and varying widely from that of the prevailing north and south traces.

The White Mountains of New Hampshire, both from their height and their northern latitude, give us reason to suppose that if local glaciers ever existed in New England, their traces would be found in the valleys of this group. The late Dr. Edward Hitchcock predicted that such would be the case. Dr. A. S. Packard, of Salem, after an examination of the eastern slope of the White Mountains, concluded that glaciers had, during some former period, radiated from the higher summits. The reader is particularly referred to his article in the first volume of this Magazine, as the glacial traces there referred to are laid down upon the map accompanying this paper, and as a section of the mountains but little known is there described.

It is to a part of the Androscoggin Valley, and to the upper part of its tributary, the Peabody River, that attention is here called, as facts plainly seen upon the ground seem to show that a glacier moved from Mount Washington down to the point where Gorham now stands, and that it joined at that place another large glacier, moving down the Androscoggin almost twenty miles, to Bethel.

The general course of the Androscoggin River, from its source to its mouth, is south-east; but this general course is made up of local courses which differ widely in direction. From its junction with the Megalloway, west of Umbagog Lake, to Gorham, thirty miles, it flows from north to south; from Gorham to Bethel, twenty miles, it flows from west to east; at Bethel it turns abruptly round and flows for six miles north, and from the point thus reached east for thirty miles, but with great local variations; thence thirty miles

south to Lewiston, and from that place twenty-five miles south-east, through Lisbon and Brunswick, to its junction with the Kennebec above Bath.

Now, while the glacial traces in the north and south reaches of this river might have been made either by the general operation which has polished off the whole country, or by a local glacier confined to the valley, such could hardly be the case with any furrows which may be found coinciding with the general direction of the east and west reaches. Let us look at the Androscoggin Valley, from Bethel in Maine, to Gorham in New Hampshire. This part of the river flows, for twenty miles, from west to east, and is bounded on both sides by abrupt hills from 1,000 to 2,000 feet high. At Bethel the valley opens, the hills receding and decreasing in elevation. Where glacial furrows are found upon the tops of the Bethel hills, they run nearly north and south. Proceeding up the valley towards Gorham, upon the south (right) bank, at a point about two and a half miles above Bethel, before we really enter the close valley, and perhaps a hundred feet above the level of the river, a small exposure of rock is seen directly in the common road, being about six feet square, with a long gently sloping polished surface towards the north, and a steep and rough face towards the south. The furrows upon the smooth northern surface run north and south, and the hills upon the summits of which the furrows run north and south, lie exactly north of this rock, upon the opposite side of the river. This furrowing had evidently no connection with the Androscoggin, as the grooves point almost directly across it. Continuing up the valley, just above Pleasant River, five miles above Bethel, about one-fourth of a mile south of the road, and perhaps two hundred feet above the river, the rocks are well polished; and from faint lines upon masses of quartz, the direction of the ice is seen to have been s. 50° e. Six miles above Bethel, where the river, railway, and road, draw closely together, and sweep round the base of Peaked Hill,

in Gilead, in the railroad cutting just between the two crossings of the common road, there is a steep ledge about twenty feet high, close to the track, which is polished and furrowed both upon the nearly vertical face towards the river, and also upon a narrow horizontal shelf part way up on the ledge. The lines upon the horizontal shelf run s. 20° E., the vertical face standing s. 25° to 30° E. It is necessary, however, to be guarded in drawing conclusions from glacial traces left upon vertical or steeply inclined surfaces; as the movement of ice, jamming through a narrow passage, may be locally disturbed, so as to give a direction to the furrows quite different from that of the general movement of the glacier. This was most likely the case at the point above referred to; as the furrows on the opposite side of the hill, *i. e.* the south side, run s. 80° E.; thus according much more nearly with the traces both above and below this point than the furrows upon the steep face towards the river do. The ice would seem to have passed around both sides of this hill; and we can readily conceive that this might be, since the depression in the rear, south of the elevation, is quite low. Indeed, in the fine view from "Sunset Rock," in Bethel, looking up the Androscoggin, Peaked Hill seems to rise in a very isolated manner from the middle of the valley, which makes it a very prominent feature in that magnificent picture.

Continuing up towards Gilead, about a mile above Peaked Hill, and eight miles from Bethel, at a point where the mountains crowd in close upon the river, there occurs a little south of the road, and it may be three hundred feet above the river, a large, steeply inclined, and magnificently polished surface, which is very plainly seen from the road a mile and a half below, as it sweeps around the western base of Peaked Hill. This surface shows a very few faint lines; but just below it may be seen well-defined furrows upon quartz, running s. 55° to 60° E. At a little more than nine miles from Bethel, upon the side of the common road, where

it bends again around a mountain spur, furrows are seen upon a small exposure running s. 80° E. At Gilead, ten miles from Bethel, just north of the railroad woodshed, and near the Androscoggin River, furrows are seen upon a highly polished surface of quartz, running s. 40° E., and a few rods east of this ledge, are some very good examples of erratic blocks; though from their lithological character they have apparently not come from any great distance. Between the railroad station and the old Wild River bridge, may be seen a good example of a polished rock, with a long, smooth, gentle slope to the north-west, and a rough, short, broken face to the south-east; but lacking indications of the precise direction of the movement of the polishing agent. About a mile above Gilead station, at the base of Mount Ephraim, where the road and the railroad draw close together and bend around the mountain, just south of and close to the road, at a small quarry, are well-marked lines in quartz, running s. 70° E.

The several traces above referred to, may be seen by reference to the map, in the positions which they occupy in respect to the course of the river. They follow the general direction of the Androscoggin Valley at this place, and are nearly at right angles with the course laid down by Dr. Packard upon the summit of Speckled Mountain (5). The remaining part of the valley, from Gilead through Shelburne to Gorham, as well as the whole reach from Gorham to Bethel upon the northern bank, invites examination; additional traces will doubtless be found, supporting the conclusion that a large glacier once moved down this portion of the Androscoggin. Especially interesting seem to be the isolated Peaked Hill (3), and the abrupt and inviting summits of Mount Ephraim, just above Wild River (4); and should no glacial traces reward the time spent in examining these points, the explorer would be amply repaid for his labor by the superb panorama which he will see spread out beneath him.

Mount Hayes, which rises about 1,200 feet above the village of Gorham, and thus 2,000 above the sea, shows upon its summit furrows running s. 40° E. This elevation affords an excellent view of portions of the Androscoggin and Peabody Valleys, and gives a more correct idea of the general relief of the surface in that region than can be obtained elsewhere. The towering pyramids of Madison and Adams are also seen from this point to great advantage, and, altogether, Mount Hayes offers every inducement to those fond of an active tramp and fine scenery.

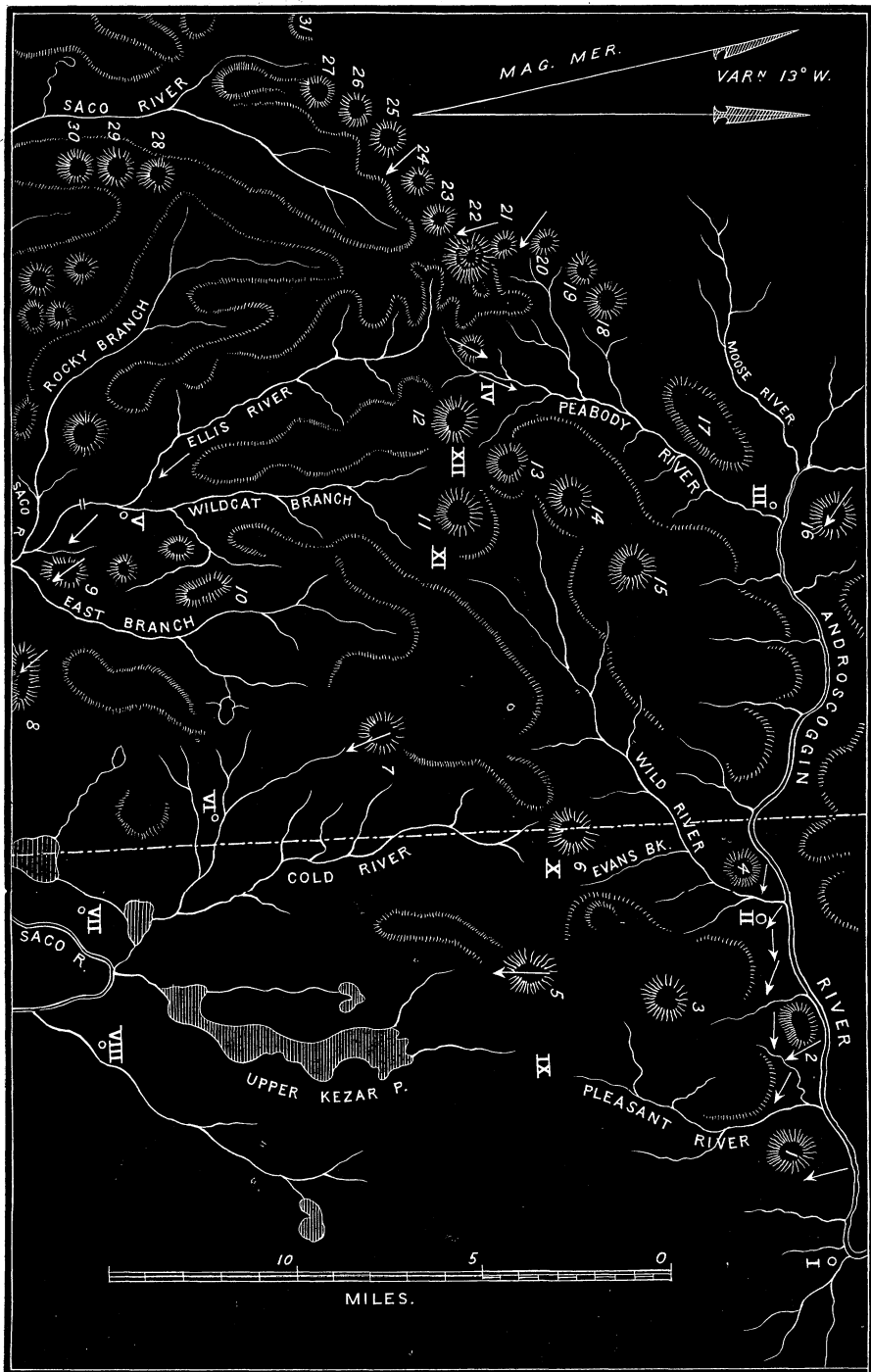
The Peabody River rises upon the eastern slopes of Madison, Adams, Jefferson, Clay, and Washington, and upon the western slopes of the opposite range of the Carter Mountains, the Imp, and Mount Moriah; and flows about N. N. E. to Gorham, where it joins the Androscoggin. The surface geology of this valley is exceedingly interesting; it has been carefully studied by Dr. Packard, and, from the arrangement of its terraces and the other forms of the unconsolidated material, he concluded that a large glacier once occupied this valley, extending as far down as to Gorham. His conclusion is somewhat confirmed by the following facts: About one hundred and fifty yards north of the Glen House, just south of a large boulder upon the west side of the road, the surface has been cut open, and has exposed a portion of a ledge, perhaps a dozen feet in length and a yard wide, on which, at right angles to the contorted lamination of the rock, faint lines, or rather furrows, are seen running N. 35° E., or S. 35° W. This ledge was covered several feet deep by the material of the terrace in front of the Glen House. Just across the valley from the hotel, where the carriage road commences to ascend, the upper part of the large exposure on the right hand is well polished and furrowed, in a south-west direction. Half a mile farther up the road, furrows upon the right side, close to the road, are seen running S. 40° W., or N. 40° E., and again a short distance above the path leading to Tuckerman's Ravine, upon a surface

somewhat inclined towards the road, may be seen lines running s. 30° w., or n. 30° e. Many more traces would doubtless be found in this neighborhood if sought for with care; as the few recorded were noted without stepping out of the common road.

Thus it appears that while the glacial furrows in the Androscoggin Valley have courses ranging from s. 20° e. to s. 80° e., those of the upper part of the Peabody Valley range from s. 30° w. to s. 40° w.; making a general difference between the courses in the two valleys of over 80° ; a difference equal to that between the two valleys themselves. We may, it would seem, thus conclude that a large glacier moved from the neighborhood of Mount Washington down towards Gorham; and that another moved from Gorham down the Androscoggin Valley, at least as far as to West Bethel.

In the depression between the higher summits of the White Mountains, especially between Clay and Jefferson, Munroe and Washington, and at the foot of Mount Franklin, the rocks are rounded and polished from the north and north-west. A little above the Lake of the Clouds, directly in the Crawford bridle-path, faintly defined furrows may be seen running nearly north and south; this point would be about 5,300 feet above the sea, according to the measurements of Professor Guyot. These elevated traces belong, not to any local glaciers, but to the general ice movement which swept over the whole of New England.

The White Mountains have been so scarred and torn by slides, the valleys so filled with rubbish, and the beds of the streams so excessively water-worn, that many of the glacial traces have most likely disappeared. Still, this region has been very little explored, and has yielded as much fruit perhaps, for the cultivation bestowed upon it, as any other. That part of the Saco Valley between Old Crawford's and Bartlett, and the parallel valley of Swift River, which drains a large area between Chocorua and the Mote Mountains, and



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enters the Saco at Conway Corner, both running nearly from west to east, deserve to be carefully studied. The valley of Wild River, too, promises to afford traces of local glaciers whenever it shall be carefully explored.

We have called attention to the few facts which we have noticed in the eastern section of the White Mountains. We do not propose to theorize upon the relation between the general and the local traces at present. We prefer to await the farther accumulation of evidence which shall enable us to restore correctly the various phases of that cold period when vast snowfields filled the White Mountain basins, and huge glaciers ploughed along the White Mountain valleys, leaving those marks upon the rocks by which we judge of their former presence, those convincing illustrations upon the last page of the geological history of the globe.

DESCRIPTION OF THE MAP.

The district embraced by the accompanying map extends from Bartlett and Kearsarge on the south, to Gorham and Mount Hayes on the north; and from Bethel, in Maine, upon the east, to the White Mountain Notch on the west. It thus includes what may be termed the eastern slope of the central mass of the White Mountain group. This general eastern slope, it will be seen by a glance at the several streams, has an irregular water-shed, running from the Pinkham Notch a little north of east for about twenty miles, and afterwards running still more north of east so as to pass a little south of Bethel. Besides the Pinkham Notch, there are four passages across this water-shed; all accessible to those who are not afraid of a little rough walking, and all full of interest to lovers of wild natural scenery. The route from Jackson to Gorham, by the Pinkham Notch and the Glen, is familiar to all; but there is another mode of passing from Jackson into the Peabody Valley which few persons have tried. This is the route up the Wildcat Branch to its western source, in the Carter Notch (xii), and thence down the stream flowing north, out of the same notch, to its junction with the Peabody River, a short distance below the Glen House.

The second passage of the water-shed is made by following up the eastern source of the Wildcat Branch, and passing through the depression (xi) and striking the head of the Wild River; this may be followed to its junction with the Androscoggin at Gilead. This trip requires two days; and in starting from Jackson, the camp for the night should be well over into the Wild River Valley: otherwise the second day's journey will be

too long, as much of it must be made in the bed of the stream, at least as far as to the State line, after which there is a good foot-road down the right bank to Gilead.

The third passage is the one described by Dr. Packard, in the first volume of this Magazine, p. 265-267, from Chatham up the Cold River to Gilead. Chatham may be reached by crossing over the mountains from Jackson (v), or by going north from Lovell (viii) or North Fryeburg (vii).

The fourth passage is from Lovell up either side of Kezar Pond, through Miles' Notch (ix), and thence by Pleasant River to West Bethel on the Androscoggin.

The Roman numerals upon the map indicate the following points: i. Bethel; ii. Gilead; iii. Gorham; iv. The Glen House; v. Jackson; vi. Chatham; vii. North Fryeburg; viii. Lovell; ix. Miles' Notch; x. Evans' Notch; xi. Wild River Notch; xii. Carter Notch. The additional figures serve to define the following separate mountains: 1. Sparrow Hawk, in West Bethel; 2. Peaked Hill, in Gilead; 3. Calabo, in Mason; 4. Mount Ephraim, in Gilead; 5. Speckled Mountain, in Stoneham; 6. Mount Royce, 7. Baldface, both in Chatham; 8. Kearsarge, in Chatham and Bartlett; 9. Thorn Mountain, in Bartlett and Jackson; 10. Double-head, in Jackson; 11. Name unknown; 12. Wildcat; 13. South peak of Carter; 14. North peak of Carter, or Imp; 15. Moriah: these five last-named mountains are in the tract between Jackson and Shelburne, called Bean's Purchase; 16. Mount Hayes; 17. Camel's Hump, in Gorham; 18. Madison; 19. Adams; 20. Jefferson; 21. Clay; 22. Washington; 23. Munroe; 24. Franklin; 25. Pleasant; 26. Clinton; 27. Jackson; 28. Giant's Stairs; 29. Mount Resolution; 30. Mount Crawford, and 31. Mount Willard. The fourteen peaks last named lie in land granted to individuals, but never made into townships. Mount Crawford, Resolution, and Giant's Stairs lie in the old route, now abandoned, from old Crawford's to the summit of Mount Washington, joining the present Crawford bridle-path east of Mount Munroe.

The following figures show the elevation above the sea of some of the principal points upon the map, according to the barometrical measurements of Professor Guyot:

Androscoggin River, at Bethel, Me., ...	632 ft.
Railroad Station, at Gorham, N. H., ...	802
Glen House, ...	1,632
Peabody River, opposite Glen House, ...	1,543
Summit of road, Pinkham Notch, near Glen Ellis' Falls, ...	2,018
Hotel at Jackson, ...	771
Road at Junction of Saco and Ellis Rivers, ...	576
Old Crawford's (Davis'), ...	986
Wiley House, White Mountain Notch, ...	1,335
Crawford House, White Mountain Notch, ...	1,920
Mount Clinton (26 on map), ...	4,320
Gap between Clinton and Pleasant, ...	4,050
Mount Pleasant (25 on map), ...	4,764

Gap between Pleasant and Franklin, ...	4,400 ft.
Mount Franklin (24 on map), ...	4,904
Mount Munroe (23 on map), ...	5,384
Gap between Munroe and Washington, ...	5,100
Lake of the Clouds, foot of Munroe, ...	5,009
Mount Washington (22 on map), ...	6,288
Gap between Washington and Clay, ...	5,417
Mount Clay (21 on map), ...	5,553
Gap between Clay and Jefferson, ...	4,979
Mount Jefferson (20 on map), ...	5,714
Gap between Jefferson and Adams, ...	4,939
Mount Adams (19 on map), ...	5,794
Gap between Adams and Madison, ...	4,912
Mount Madison (18 on map), ...	5,365
Limit of trees on north side of Washington, and on Madison, ...	4,150
Limit of trees on Clinton, ...	4,250
Mount Hayes (approximate) (16 on map), ...	2,000
Mount Moriah (15 on map), ...	4,653
Carter Mountain, north peak, or Imp (14 on map), ...	4,702
Carter Mountain, south peak (13 on map), ...	4,830
Wildcat Mountain (12 on map), ...	4,350
Double-head, north peak } (10 on map), ...	{ 3,100
Double-head, south peak }	{ 3,000
Kearsarge (8 on map), ...	3,500
Thorn Mountain (9 on map), ...	2,500
Giant's Stairs (28 on map), ...	3,500
Mount Resolution (29 on map), ...	3,400
Mount Crawford (30 on map), ...	3,134
Mount Jackson (27 on map), ...	4,100
Mount Webster (south of 27), ...	4,000

NOTE.—There are few persons among those who visit the Mountains who could not aid in obtaining evidence of former glaciers, if they were so disposed. A very little study will enable one to recognize the marks upon the rocks where they occur. A small compass and a piece of thread, the latter to be stretched along the furrow and over the centre of the compass, are the only things needed. Notes thus obtained, and recorded carefully and conscientiously upon the spot, are always valuable. In all cases the magnetic meridian should be used; and the correction for declination, according to the year and the location, applied afterwards: the use of two meridians in the field leads to confusion. The date, too, should always be affixed. It is well, also, to check the magnetic needle, for local disturbance, by taking the bearing to some known feature in the landscape when such exists; and where two points, the exact positions of which are known, can be seen, by taking the bearing of both of them, the place of the observer is easily determined; so that the point of his observation may be laid down upon the map. Glacial traces may be rubbed off from the stone itself, when it is somewhat smooth, in the same manner as children obtain the figure from a coin. Such impressions are often very satisfactory; being taken from Nature's own engraving. The meridian should be put upon the paper before it is moved from the stone in the above operation.